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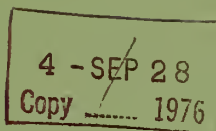
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**Basic Estimated Capital Investment
and Operating Costs for Underground
Bituminous Coal Mines Developed
for Longwall Mining**

**Mines With Annual Production of 1.5 and 3
Million Tons by Longwall Mining
From an 84-Inch Coalbed**



UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. Bureau of Mines

Information Circular 8715

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Million Tons by Longwall Mining
From an 84-Inch Coalbed**

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**UNITED STATES DEPARTMENT OF THE INTERIOR
Thomas S. Kleppe, Secretary
BUREAU OF MINES
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BASIC ESTIMATED CAPITAL INVESTMENT AND OPERATING COSTS FOR UNDERGROUND BITUMINOUS COAL MINES DEVELOPED FOR LONGWALL MINING

Mines With Annual Production of 1.5 and 3 Million Tons by Longwall
Mining From an 84-Inch Coalbed

by

John R. Duda¹ and E. L. Hemingway²

ABSTRACT

The Bureau of Mines is developing estimates of capital investment, operating cost, and selling price for underground mines producing bituminous coal by various mining methods. This study estimates the required capital investment, operating costs, and selling prices for two hypothetical mines designed to produce 1.5 and 3 million tons per year (MM tpy)³ by using a longwall system in conjunction with a continuous-mining system. The coal properties being mined are assumed capable of sustaining a 20-year production period. Wages and union welfare payments used in this study are those in effect as of December 6, 1975, as set forth under the National Bituminous Coal Wage Agreement of 1974. Costs of materials and equipment are based on January 1976 indexes.

Initial capital investment is \$33.8 million for the 1.5-MM-tpy mine and \$61 million for the 3-MM-tpy mine. Capital requirements, including deferred investments, were estimated to be \$52.5 and \$94.2 million, respectively. These figures translate into total capital investments of \$34.87 and \$31.31 per ton of annual production. Assuming a desired 15-percent discounted cash flow rate of return, with Federal income taxes at 50 percent, the required selling prices would be \$12.06 and \$10.94 per ton for the 1.5- and 3-MM-tpy mines.

INTRODUCTION

The diminishing availability of energy sources compared with the demand and the fact that coal represents the most abundant fossil energy resource have renewed interest in coal production in the United States. Since economics is an important factor in determining the extent to which any fuel will be used to satisfy the energy requirement, the Bureau of Mines is preparing a series of reports that provide estimated capital investment and operating

¹Petroleum engineer.

²Mining engineer.

³Actual tonnages produced and used in calculations throughout the report are 1.50 and 3.01 MM tpy.

costs for hypothetical underground bituminous coal mines utilizing various mining methods.

No consideration is given to the costs of loading and transportation facilities or coal preparation.

GENERAL MINING PLAN

The mines are assumed to operate three shifts per day, 5 days per week, and 220 days per year, and to have a 20-year life. Continuous-miner units used to develop working panels for the longwall units operate at a rate of 340 tons per unit per shift, mining 72 inches of coal; the longwall units are designed to mine 84 inches of coal at a nominal rate of 800 tons per unit per shift.

Using a 70-percent combined recovery factor for the continuous-longwall system, and assuming 1,830 tons of coal per acre-foot with a 20-year life, 3,514 acres of coal resource are required for the 1.5-MM-tpy mine and 7,060 acres for the 3-MM-tpy mine.

The general mining plan involves driving the main heading, production heading, bleeders, and development entries with borer-type continuous-mining units. Shearer-type longwall mining units are used to extract coal from the panels developed by continuous units. The borer miners drive the main entries up the central axis of the property, turning production headings to the right and left. In the 1.5-MM-tpy mine, all mining is assumed to be concentrated to one side of the mains, the plan being to mine one side of the main entries while developing the overall mine property, and then mine the other side on the retreat. All longwall panels will be mined with a retreating face. In the 3-MM-tpy mine, production headings are assumed to be driven simultaneously to the right and left off the main headings to reduce development time while reaching full production with the required number of units.

The main heading has 10 entries, the production heading 5 entries, the bleeders 4 entries, and the panels developed for the longwall units 3 entries, all driven by the continuous-miner units. These entries are 13-foot-wide arches, driven on 90-foot centers. The longwall production panels are 450 feet wide and 2,600 feet long. An additional length for development of the bleeder system and barriers is included. Figure 1 is a diagram of the general mining plan developed for the 1.5-MM-tpy mine using two continuous and two longwall units. The 3-MM-tpy mine uses four continuous and four longwall units when fully developed. Each mine has one spare continuous unit included in the capital investment.

Each continuous-loading unit consists of a continuous miner, a loading machine, two shuttle cars, and a roof bolter. The continuous miner dumps the coal on the bottom, and the loading machine loads the coal into the shuttle cars, which dump into a ratio feeder at the tailpiece of the unit belt conveyor; unit manpower consists of 10 men and a foreman. Each longwall unit consists of a double-drum shearer, the required number of self-advancing roof chocks, a face conveyor, a stage loader, and the required controls and

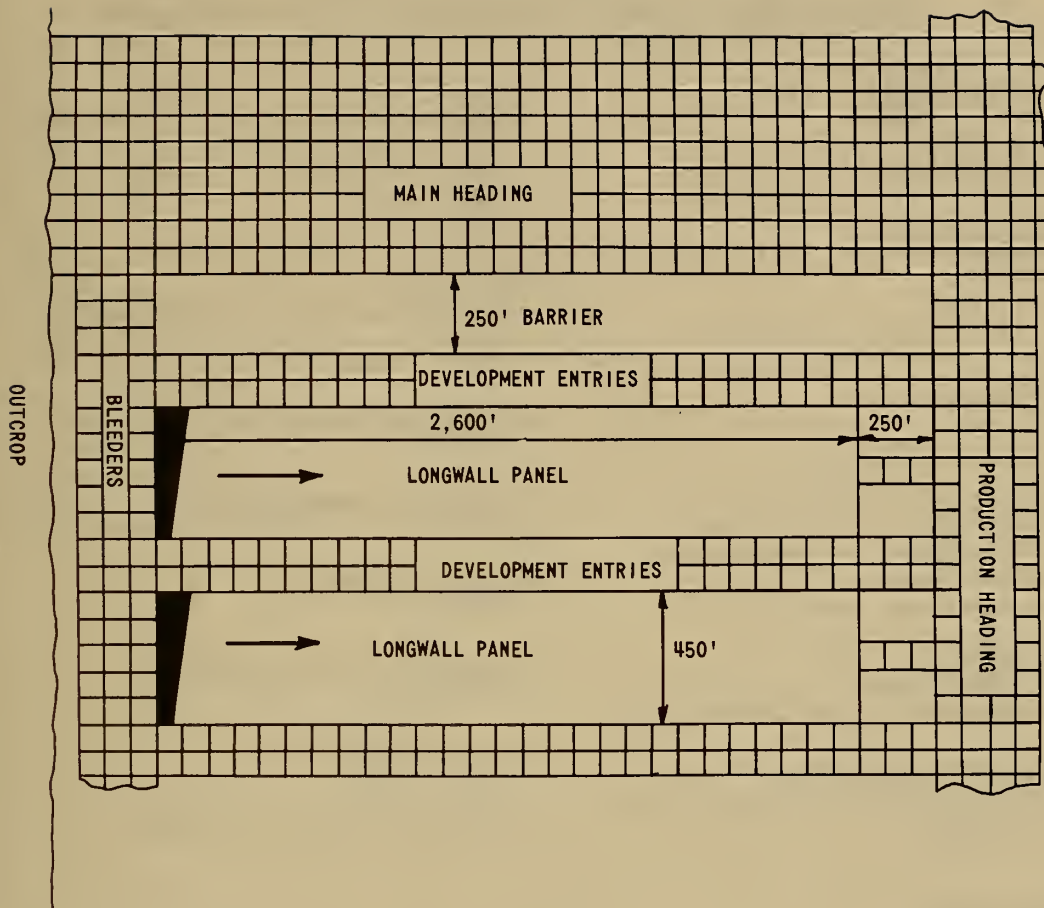


FIGURE 1. - General mining plan.

accessories; unit manpower is eight men and a foreman. All units are equipped with power centers to reduce the high voltage to equipment requirements. A rectifier converts alternating to direct current where necessary. The coal produced is assumed to be transported to the surface by 36-inch belt conveyors.

The following detailed equipment list describes the principal pieces of equipment to be used in the mines:

Continuous miner

Type: Boring.
Hp: 600.
Drive: Motor.

Loading machine

Loading rate: 25 to 30 tons per minute.
Hp: 160.
Drive: Motor.

Shuttle car

Hp: 135.
Drive: Motor.

Ratio feeder

Can accept 15+ tons of coal discharge at the desired rate.
Self-tramming.
Equipped with lumpster.

Auxiliary fan

To provide more effective ventilation at the working face.

Triple-duty rock duster

To dust main heading, faces, and back area.
Hp: 30.

Roof bolter

Dual boom.
Hp: 50.
Equipped with lumpster.

Longwall unit

Double-drum shearer.
350-ton-capacity chocks.
Single-strand chain conveyor.
Stage loader.
Hp: 1,200.

Supply motor

To haul supplies to working faces.
Hp: 80.
Drive: Motor.

Mainline belt power center

300 kva.

Section belt power center

150 kva.

Section rectifier

200 kva.

Rectifier for track haulage

1,000 kw.

Main ventilation fan

Type: Dual.
Size: 8 ft.
350 cfm at 6-inch water gage.

SUMMARY

This study furnishes cost analyses for two hypothetical underground bituminous mines utilizing a combined continuous-longwall method to produce 1.5 and 3 million tons per year of coal. Table 1 summarizes the total capital investments, operating costs, and selling prices.

TABLE 1. - Summary of capital investment, operating costs,
and selling price by annual output capacity

	Tons per year	
	1,504,800	3,009,600
Estimated capital investment:		
Initial.....	\$33,835,100.00	\$60,952,000.00
Deferred.....	18,639,400.00	33,282,700.00
Total.....	52,474,500.00	94,234,700.00
Capital investment per ton of production.....	34.87	31.31
Operating cost:		
Per year.....	11,934,400.00	21,609,800.00
Per ton of production.....	7.93	7.18
Selling price per ton:		
12-percent DCF ¹	11.01	9.99
15-percent DCF ¹	12.06	10.94
20-percent DCF ¹	13.87	12.58

¹Discounted cash flow.

APPENDIX A.--1.5-MM-TPY MINE

TABLE A-1. - Tonnage study, 1.5-MM-tpy mine

5 days per week.
 3 shifts per day.
 220 days per year.
 20-year life.

Continuous-miner sections (will mine 72 inches of coal):

2 units at 340 tons run-of-mine (ROM) per unit x 3 shifts per day
 = 2,040 tons per day (tpd).

2,040 x 220 days per year = 448,800 tons per year (tpy).

Longwall units (will mine full seam--84 inches of coal):¹

2 units at 800 tons nominal ROM per unit x 3 shifts = 4,800 tpd.

4,800 x 220 days per year = 1,056,000 tpy.

Total tonnage = 448,800 + 1,056,000 = 1,504,800 tpy.

640 acres = 1 square mile.

1,830 tons per acre-ft.

1,830 x 6 ft = 10,980 tons per acre for 72-inch coal.

1,830 x 7 ft = 12,810 tons per acre for 84-inch coal.

448,800 ÷ 10,980 = 40.9 acres per year = 41 acres per year.

1,056,000 ÷ 12,810 = 82.4 acres = 82 acres per year.

Total acres per year = 123.

123 x 20 = 2,460 acres over 20 years.

At 70-percent combined recovery--longwall and continuous--
 acres required = 2,460 ÷ 0.7 = 3,514.

NOTE: Use 1 spare continuous-miner unit.

¹Longwall units will have 3.2 moves/year/unit and each move will require 30 shifts. Also, 20 shifts/year/unit are allowed for major maintenance. This leaves a net of 544 shifts/year/unit of actual mining. Actual mining rate is 970 tons/unit/shift--544 shifts/unit/year. 970 tons/unit/shift x 544 shifts/unit/year x 2 units = 1,056,000 tpy.

TABLE A-2. - Capital investment summary, 1.5-MM-tpy mine

Item	Quantity	Total cost
Longwall unit ¹	2	\$7,000,000
Continuous miner.....	3	1,022,100
Loading machine.....	3	267,600
Shuttle car.....	6	558,600
Roof bolter.....	4	265,200
Ratio feeder.....	3	168,000
Auxiliary fan.....	3	14,100
Mantrip Jeep ²	4	87,200
Mechanic Jeep.....	3	51,300
Personnel Jeep.....	4	62,400
Triple-duty rock duster.....	3	144,600
Trickle duster.....	3	16,200
Supply motor.....	3	116,700
Supply car.....	30	117,000
36-inch rope-type conveyor for main and production headings.....	24,000 ft	2,054,400
Mainline belt power center (300 kva).....	3	116,700
Section belt power center (150 kva).....	5	78,000
Section power center (1,000 kva).....	5	179,000
Section rectifier (200 kw).....	5	15,500
Section switch house.....	5	58,500
Sectionalizing switch house.....	5	58,500
High-voltage cable (300 million circular mill aluminum [MCM AL]).....	27,500 ft	342,400
PLM coupler.....	15	18,000
Section cable and coupler.....		58,000
Rectifier for track haulage.....		31,100
Trolley wire.....	27,500 ft	107,300
Track.....	27,500 ft	342,400
Freshwater line.....	27,500 ft	127,900
Pumps and lines.....		23,300
Telephone (page phones).....		10,900
Conveyor fire protection.....		31,100
Automatic controls and alarms.....		62,200
Scoop tractor.....	3	116,700
Battery charger.....	3	9,300
All-service mask.....	12	1,900
Breathing apparatus.....	12	12,000
Self-rescuer.....	210	10,500
Stretcher set.....	8	1,600
Safety light.....	100	5,500
Methanometer.....	100	48,000
Fire chemical car.....	4	18,800
Lamp (including accessories).....	210	13,700
Dust sampler.....	15	7,100
Site preparation.....		31,100
Ventilation fan (dual).....	1	143,100

See footnotes at end of table.

TABLE A-2. - Capital investment summary, 1.5-MM-tpy mine--Continued

Item	Quantity	Total cost
Concrete portal.....	3	\$65,400
Bulk rock dust facility.....	1	23,300
Substation and distribution.....	1	101,100
Bathhouse, office, and lamp house.....	1	432,500
Shop and warehouse.....	1	233,400
Powder and cap house.....	1	7,800
Front-end loader.....	1	77,800
Forklift.....	1	31,100
Bulldozer.....	1	124,500
Utility truck.....	1	6,200
Pickup truck.....	1	4,700
Oil storage.....	1	15,600
Water tank.....	1	15,600
Supply yard.....	1	15,600
Mine drainage treatment plant.....		46,700
Exploration.....		77,800
Landscaping (around physical plant).....		10,500
Roads and parking lots (assume 1/2-mile road and parking lot).....		50,000
Total direct.....		15,365,100
Field indirect.....		307,300
Total construction.....		15,672,400
Engineering.....		313,400
Overhead and administration.....		799,300
		16,785,100
Contingency.....		2,517,800
		19,302,900
Fee.....		386,100
		19,689,000
Estimated development cost.....		6,704,300
		26,393,300
Interest during development.....		1,319,700
Gross estimate.....		27,713,000
Credit for coal mined during development at \$12 per ton.....		5,108,800
		22,604,200
Coal property acquired at \$2,500 per acre x 3,514 acres.....		8,785,000
Net estimate.....		31,389,200
1Roof support--90 units on 5-ft centers at \$25,000/unit = \$2,250,000		
Shearer.....	=	535,000
Face accessories.....	=	290,000
Chain face conveyor and accessories.....	=	145,000
Hydraulic powerpack, electrical controls, stage loader, face lighting, electric motors, and accessories.....	=	280,000
Total longwall unit.....	=	3,500,000

2Reference to specific trade names is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.

TABLE A-3. - Manning table, 1.5-MM-tpy mine

Personnel	Total	Wages ¹ per day	Cost per year	Cost per ton
Underground:				
Longwall units:				
Shearer operator.....	6	\$59.52	\$79,799	
Shearer operator helper.....	6	56.38	75,653	
Chock setter.....	12	53.52	143,758	
Headgate man.....	6	56.38	75,653	
Utility man.....	12	53.52	143,758	
Mechanic.....	6	59.52	79,799	
Continuous-miner units:				
Continuous-miner operator.....	6	59.52	79,799	
Loading machine operator.....	6	56.38	75,653	
Machine operator helper.....	6	56.38	75,653	
Shuttle car operator.....	12	53.52	143,758	
Roof bolter.....	12	59.52	159,598	
Utility man.....	6	53.52	71,879	
Mechanic.....	6	59.52	79,799	
Bratticeman.....	6	51.23	68,855	
Total.....	108		1,353,414	\$0.90
Supply motorman.....	4	51.80	46,112	
Beltman.....	12	51.23	137,710	
Trackman.....	2	51.23	22,541	
Wireman.....	2	51.23	22,541	
Mason (precision).....	4	53.52	47,626	
Pumper.....	3	51.23	34,429	
Utility man.....	6	53.52	71,879	
Roving mechanic.....	6	59.52	79,799	
Fireboss (union).....	3	59.52	39,898	
Total.....	42		502,535	.33
Outside:				
Lampman.....	3	49.52	33,298	
Front-end loader operator.....	2	52.08	23,180	
Shop mechanic.....	6	53.80	72,248	
Total.....	11		128,726	.09
Salary:				
Superintendent.....	1		33,000	
General mine foreman.....	1		22,000	
Assistant mine foreman.....	3		52,800	
Section foreman.....	12		215,600	
Maintenance superintendent.....	1		24,000	
General shop foreman.....	1		16,700	
Mine maintenance foreman.....	3		49,500	
Chief mine engineer.....	1		24,800	
Draftsman.....	1		10,100	
Survey crew.....	3		32,700	
Safety director.....	1		21,800	

¹Figures in this column are for the day shift. Shift differentials for other shifts are reflected in the cost per year.

TABLE A-3. - Manning table, 1.5-MM-tpy mine--Continued

Personnel	Total	Wages per day	Cost per year	Cost per ton
Safety inspector.....	3		\$48,000	
Dust sampler.....	3		34,800	
Office manager.....	1		17,400	
Timekeeper and bookkeeper..	1		12,100	
Purchasing supervisor.....	1		17,400	
Warehouseman.....	4		43,600	
Total.....	41		676,300	\$0.45
Total labor and supervision.....	202		22,661,000	1.77

²Rounded to nearest \$100.

TABLE A-4. - Depreciation schedule, 1.5-MM-tpy mine

Item	Straight-line depreciation, years	Yearly charge, dollars
Exploration.....	20	3,900
Mine drainage treatment plant.....	10	4,700
Landscaping.....	20	500
Roads and parking lots.....	20	2,500
Supply yard.....	10	1,600
Water tank.....	10	1,600
Oil storage.....	10	1,600
Pickup truck.....	5	900
Utility truck.....	5	1,200
Bulldozer.....	10	12,500
Forklift.....	10	3,100
Front-end loader.....	10	7,800
Powder and cap house.....	10	800
Shop and warehouse.....	20	11,700
Bathhouse, office, and lamp house.	20	21,600
Substation.....	20	5,100
Bulk rock dust facility.....	10	2,300
Concrete portal.....	20	3,300
Ventilation fan.....	20	7,200
Site preparation.....	20	1,600
Coal mine safety equipment.....	5	39,700
Underground equipment.....	10	1,365,300
Interim equipment replacement.....	20	200,000
Total.....		1,700,500
Depreciation for field indirect, engineering, overhead and administration, contingency, fee, cost of development, and interest during development, less credit for coal mined at \$12 per ton.....	20	362,000
Grand total.....		12,062,500

¹\$1.37 per ton.

TABLE A-5. - Power and water requirements, 1.5-MM-tpy mine

Number of units	Operation	Hp per unit	Hp, total load	Hr per day, full load	Kw, total load	Total kwhr requirement
2	Longwall units.....	1,200	2,400	16	1,790	28,640
2	Continuous miner.....	600	1,200	10	895	8,950
2	Loading machine.....	160	320	10	239	2,390
4	Shuttle car.....	135	540	10	403	4,030
2	Roof bolter.....	50	100	12	75	900
2	Ratio feeder.....	125	250	10	187	1,870
2	Auxiliary fan.....	15	30	18	22	396
4	Mantrip Jeep.....	15	60	4	45	180
3	Mechanic Jeep.....	15	45	15	34	510
4	Personnel Jeep.....	7.5	30	15	22	330
3	Supply motor.....	80	240	12	179	2,148
3	Rock duster.....	30	90	12	67	804
8	36-inch belt conveyor	100	800	16	597	9,552
1	Ventilation fan.....	500	500	24	373	8,952
	Extra for pumps, bolting, etc.....		400	10	298	2,980
	Shops, lighting, etc.			24	268	6,432
	Total.....					79,064

NOTE:--Power at \$0.015 per kwhr.

= $\$0.015 \times 79,064 \times 220 \text{ day per year} = \$260,900.$

Water at \$0.15 per 1,000 gallons:

Continuous-miner units at 3,000 gallons per unit per shift
 = $(3,000 \times 6 \times 220 \times 0.15) \div 1,000 = \$600 \text{ per year}.$

Longwall units at 6,000 gallons per unit per shift
 = $(6,000 \times 6 \times 220 \times 0.15) \div 1,000 = \$1,200 \text{ per year}.$

Outside water, showers, etc., at 30 gallons per man-day
 = $(30 \times 220 \times 202 \times 0.15) \div 1,000 = \$200 \text{ per year}.$

Total water cost = $\$600 + \$1,200 + \$200 = \$2,000 \text{ per year}.$

TABLE A-6. - Estimated annual operating cost, 1.5-MM-tpy mine

	Annual cost	Cost per ton
Direct cost:		
Production:		
Labor.....	\$1,673,000	\$1.11
Supervision.....	586,100	.39
Total.....	2,259,100	1.50
Maintenance:		
Labor.....	311,700	.21
Supervision.....	90,200	.06
Total.....	401,900	.27
Operating supplies:		
Mining machine parts.....	1,075,100	.71
Lubrication and hydraulic oil.....	268,900	.18
Roof bolts and timber.....	483,900	.32
Rock dust.....	268,900	.18
Ventilation.....	403,100	.27
Bits.....	131,900	.09
Cables.....	83,900	.06
Miscellaneous.....	164,900	.11
Total.....	2,880,600	1.92
Power.....	260,900	.17
Water.....	2,000	
Payroll overhead (40 percent of payroll).....	1,064,400	.71
Union welfare ¹	1,570,400	1.04
Indirect cost:		
15 percent of labor, supervision, and supplies.....	831,200	.55
Fixed cost:		
Taxes and insurance, 2 percent of mine cost.....	601,400	.40
Depreciation.....	2,062,500	1.37
Total.....	2,663,900	1.77
Grand total.....	11,934,400	7.93

¹Effective Dec. 6, 1975, under the Bituminous Wage Agreement of 1974.

TABLE A-7. - Estimated development cost,¹ 1.5-MM-tpy mine

Item	Total cost	Cost per ton
Total labor and supervision.....	\$1,846,000	\$4.34
Operating supplies.....	2,060,400	4.84
Power.....	128,500	.30
Payroll overhead.....	738,400	1.73
Union welfare.....	674,600	1.58
Indirect cost.....	586,000	1.38
Fixed cost.....	670,400	1.58
Total.....	6,704,300	15.75

¹Estimated development cost covers the period of time required (1 calendar year) to place all units in operation within the projected mining plan.

NOTE: Cost per ton = \$15.75.

Tonnage = 425,736.

Credit for coal mined at \$12 per ton = \$5,108,800.

TABLE A-8. - Estimated working capital and total capital investment, 1.5-MM-tpy mine

Estimated working capital:

Direct labor.....3 months...	\$665,300
Operating supplies.....do.....	720,200
Payroll overhead.....do.....	266,100
Indirect cost.....4 months...	277,100
Fixed cost.....0.5 percent of insurance cost...	150,300
Spare parts.....	330,200
Miscellaneous.....	36,700
Total working capital.....	2,445,900

Total estimated capital investment:

Total mine cost (insurance, tax base).....	30,069,500
Interest during development.....	1,319,700
Total.....	31,389,200
Working capital.....	2,445,900
Estimated initial capital investment.....	33,835,100
Estimated deferred capital investment.....	18,639,400
Total capital and deferred investment.....	52,474,500

¹This is an average investment of \$34.87 per ton of annual production.

TABLE A-9. - Summary of discounted cash flow, 1.5-MM-tpy mine

Year	Capital investment	Cash flow	Present worth factor at 15 percent	Present worth, capital investment at 15 percent	Present worth, cash flow value at 15 percent
0	\$33,835,100	\$-33,835,100	1.	\$33,835,100	\$-33,835,100
1	200,000	5,878,700	.8696	173,900	5,112,100
2	200,000	5,878,700	.7561	151,200	4,444,900
3	200,000	5,878,700	.6575	131,500	3,865,200
4	200,000	5,878,700	.5718	114,400	3,361,400
5	409,600	5,669,100	.4972	203,700	2,818,700
6	200,000	5,878,700	.4323	86,500	2,541,400
7	200,000	5,878,700	.3759	75,200	2,209,800
8	200,000	5,878,700	.3269	65,400	1,921,700
9	200,000	5,878,700	.2843	56,900	1,671,300
10	14,420,200	-8,341,500	.2472	3,564,700	-2,062,000
11	200,000	5,878,700	.2149	43,000	1,263,300
12	200,000	5,878,700	.1869	37,400	1,098,700
13	200,000	5,878,700	.1625	32,500	955,300
14	200,000	5,878,700	.1413	28,300	830,700
15	409,600	5,669,100	.1229	50,300	696,700
16	200,000	5,878,700	.1069	21,400	628,400
17	200,000	5,878,700	.0929	18,600	546,100
18	200,000	5,878,700	.0808	16,200	475,000
19	200,000	5,878,700	.0703	14,100	413,300
20	-11,030,900	17,109,600	.0611	-674,000	1,045,400
				38,046,300	2,300

TABLE A-10. - Discounted cash flow analysis, 1.5-MM-tpy mine

15 percent - 20 years

$$R^1 = \$38,046,300 \div 6.259^2 = \$6,078,700$$

less depreciation	2,062,500
Depletion + net profit	<u>4,016,200</u>

Depletion = 10 percent of sales

Federal income tax = net profit

Depletion + net profit = cash flow - depreciation

$$\begin{aligned} \text{Sales} &= 1.0/0.55 \left(\frac{1}{2} \text{ operating cost} + \text{cash flow} - \text{depreciation} \right) \\ &= 1/0.55 \left[\left(\frac{1}{2} \times \$11,934,400 \right) + \$4,016,200 \right] \\ &= 1/0.55 (\$9,983,400) \\ &= \$18,151,600 \end{aligned}$$

Sales.....	\$18,151,600
Operating cost.....	<u>11,934,400</u>
Gross profit.....	6,217,200
Depletion.....	<u>-1,815,200</u>
Taxable income.....	4,402,000
Federal income tax.....	<u>-2,201,000</u>
Net profit.....	2,201,000

$$\begin{aligned} \text{Annual cash flow} &= \text{net profit} + \text{depletion} + \text{depreciation} \\ &= \$2,201,000 + \$1,815,200 + \$2,062,500 \\ &= \$6,078,700 \end{aligned}$$

$$\text{Selling price per ton} = \$18,151,600 \div 1,504,800 = \$12.06$$

¹R is total annual net cash flow required to give indicated rate of return in time specified.

²Uniform series present worth factor.

APPENDIX B.--3-MM-TPY MINE

TABLE B-1. - Tonnage study, 3-MM-tpy mine

5 days per week.
 3 shifts per day.
 220 days per year.
 20-year life.

Continuous-miner sections (will mine 72 inches of coal):
 4 units at 340 tons run-of-mine (ROM) per unit x 3 shifts per day
 = 4,080 tons per day (tpd).
 $4,080 \times 220 \text{ days per year} = 897,600 \text{ tons per year (tpy)}.$

Longwall units (will mine full seam--84 inches of coal):¹
 4 units at 800 tons nominal ROM per unit x 3 shifts = 9,600 tpd.
 $9,600 \text{ tpd} \times 220 \text{ days per year} = 2,112,000 = 3,009,600 \text{ tpy}.$

Total tonnage = $897,600 + 2,112,000 = 3,009,600 \text{ tpy}.$

640 acres = 1 square mile.
 1,830 tons per acre-ft.
 $1,830 \times 6 \text{ ft} = 10,980 \text{ tons per acre for 72-inch coal}.$
 $1,830 \times 7 \text{ ft} = 12,810 \text{ tons per acre for 84-inch coal}.$
 $897,600 \div 10,980 = 81.75 \text{ acres per year} = 82 \text{ acres per year}.$
 $2,112,000 \div 12,810 = 164.9 \text{ acres} = 165 \text{ acres per year}.$

Total acres per year = $82 + 165 = 247.$

$247 \times 20 = 4,940 \text{ acres over 20 years}.$

At 70-percent combined recovery--longwall and continuous--
 acres required = $4,940 \div 0.7 = 7,060 \text{ acres}.$

NOTE: Use 1 spare continuous-miner unit.

¹Longwall units will have 3.2 moves/year/unit and each move will require 30 shifts. Also, 20 shifts/year/unit are allowed for major maintenance. This leaves a net of 544 shifts/year/unit of actual mining. Actual mining rate is 970 tons/unit/shift--544 shifts/unit/year.
 $970 \text{ tons/unit/shift} \times 544 \text{ shifts/unit/year} \times 4 \text{ units} = 3,009,600 \text{ tpy}.$

TABLE B-2. - Capital investment summary, 3-MM-tpy mine

Item	Quantity	Total cost
Longwall unit.....	4	\$14,000,000
Continuous miner.....	5	1,703,500
Loading machine.....	5	446,000
Shuttle car.....	10	931,000
Roof bolter.....	6	397,800
Ratio feeder.....	5	280,000
Auxiliary fan.....	5	23,500
Mantrip Jeep.....	8	174,400
Mechanic Jeep.....	6	102,600
Personnel Jeep.....	6	93,600
Triple-duty rock duster.....	5	241,000
Trickle duster.....	5	27,000
Supply motor.....	3	116,700
Supply car.....	40	156,000
36-inch rope-type conveyor for main and production headings.....	36,000 ft	3,081,600
Mainline belt power center (300 kva).....	4	155,600
Section belt power center (150 kva).....	9	140,400
Section power center (1,000 kva).....	9	322,200
Section rectifier (200 kw).....	9	27,900
Section switch house.....	9	105,300
Sectionalizing switch house.....	9	105,300
High-voltage cable (300 MCM AL).....	47,500 ft	591,400
PLM coupler.....	27	32,400
Section cable and coupler.....		116,000
Rectifier for track haulage.....		31,100
Trolley wire.....	47,500 ft	185,300
Track.....	47,500 ft	591,400
Freshwater line.....	47,500 ft	220,900
Pumps and lines.....		35,000
Telephone (page phones).....		16,400
Conveyor fire protection.....		46,700
Automatic controls and alarms.....		93,300
Scoop tractor.....	5	194,500
Battery charger.....	5	15,500
All-service mask.....	18	2,900
Breathing apparatus.....	18	18,000
Self-rescuer.....	380	19,000
Stretcher set.....	12	2,400
Safety light.....	150	8,300
Methanometer.....	150	72,000
Fire chemical car.....	6	28,200
Lamp (including accessories).....	380	24,700
Dust sampler.....	24	11,300
Site preparation.....		56,000
Ventilation fan (dual).....	1	257,600

TABLE B-2. - Capital investment summary, 3-MM-tpy mine--Continued

Item	Quantity	Total cost
Concrete portal.....	3	\$65,400
Bulk rock dust facility.....	1	41,900
Substation and distribution.....	1	182,000
Bathhouse, office, and lamp house.....	1	778,500
Shop and warehouse.....	1	420,100
Powder and cap house.....	1	14,000
Front-end loader.....	1	77,800
Forklift.....	1	31,100
Bulldozer.....	1	124,500
Utility truck.....	1	6,200
Pickup truck.....	1	4,700
Oil storage.....	1	28,100
Water tank.....	1	28,100
Supply yard.....	1	28,100
Mine drainage treatment plant.....		84,100
Exploration.....		140,000
Landscaping (around physical plant)....		14,000
Roads and parking lots (assume 1/2-mile road and parking lot).....		62,500
Total direct.....		27,432,800
Field indirect.....		548,700
Total construction.....		27,981,500
Engineering.....		559,600
Overhead and administration.....		1,427,100
		29,968,200
Contingency.....		4,495,200
		34,463,400
Fee.....		689,300
		35,152,700
Estimated development cost.....		9,251,000
		44,403,700
Interest during development.....		2,220,200
Gross estimate.....		46,623,900
Credit for coal mined during develop- ment at \$12 per ton.....		7,712,700
		38,911,200
Coal property acquired at \$2,500 per acre x 7,060 acres.....		17,650,000
Net estimate.....		56,561,200

TABLE B-3. - Manning table, 3-MM-tpy mine

Personnel	Total	Wages ¹ per day	Cost per year	Cost per ton
Underground:				
Longwall units:				
Shearer operator.....	12	\$59.52	\$159,598	
Shearer operator helper.....	12	56.38	151,306	
Chock setter.....	24	53.52	287,516	
Headgate man.....	12	56.38	151,306	
Utility man.....	24	53.52	287,516	
Mechanic.....	12	59.52	159,598	
Continuous-miner units:				
Continuous-miner operator...	12	59.52	159,598	
Loading machine operator....	12	56.38	151,306	
Machine operator helper.....	12	56.38	151,306	
Shuttle car operator.....	24	53.52	287,516	
Roof bolter.....	24	59.52	319,196	
Utility man.....	12	53.52	143,758	
Mechanic.....	12	59.52	159,598	
Bratticeman.....	12	51.23	137,710	
Total.....	216		2,705,828	\$0.90
Supply motorman.....		51.80		
Beltman.....	15	51.23	172,139	
Trackman.....	4	51.23	45,082	
Wireman.....	4	51.23	45,082	
Mason (precision).....	8	53.52	95,252	
Pumper.....	3	51.23	34,429	
Utility man.....	15	53.52	179,696	
Roving mechanic.....	15	59.52	199,496	
Fireboss (union).....	3	59.52	39,898	
Total.....	73		880,682	.29
Outside:				
Lampman.....	3	49.52	33,298	
Front-end loader operator.....	3	52.08	34,990	
Shop mechanic.....	15	53.80	180,620	
Total.....	21		248,908	.08
Salary:				
Superintendent.....	1		33,000	
General mine foreman.....	1		22,000	
Assistant mine foreman.....	3		52,800	
Section foreman.....	24		431,200	
Maintenance superintendent....	1		24,000	
General shop foreman.....	1		16,700	
Mine maintenance foreman.....	3		49,500	
Chief mine engineer.....	1		24,800	
Draftsman.....	1		10,100	
Survey crew.....	3		32,700	
Safety director.....	1		21,800	

¹Figures in this column are for the day shift. Shift differentials for other shifts are reflected in the cost per year.

TABLE B-3. - Manning table, 3-MM-tpy mine--Continued

Personnel	Total	Wages per day	Cost per year	Cost per ton
Safety inspector.....	3		\$48,000	
Dust sampler.....	3		34,800	
Office manager.....	1		17,400	
Timekeeper and bookkeeper.	2		24,200	
Purchasing supervisor.....	1		17,400	
Warehouseman.....	6		65,400	
Total.....	56		925,800	\$0.31
Total labor and supervision.....	366		24,762,200	1.58

²Rounded to nearest \$100.

TABLE B-4. - Depreciation schedule, 3-MM-tpy mine

Item	Straight-line depreciation, years	Yearly charge, dollars
Exploration.....	20	7,000
Mine drainage treatment plant....	10	8,400
Landscaping.....	20	700
Roads and parking lots.....	20	3,100
Supply yard.....	10	2,800
Water tank.....	10	2,800
Oil storage.....	10	2,800
Pickup truck.....	5	900
Utility truck.....	5	1,200
Bulldozer.....	10	12,500
Forklift.....	10	3,100
Front-end loader.....	10	7,800
Powder and cap house.....	10	1,400
Shop and warehouse.....	20	21,000
Bathhouse, office, and lamp house	20	38,900
Substation.....	20	9,100
Bulk rock dust facility.....	10	4,200
Concrete portal.....	20	3,300
Ventilation fan.....	20	12,900
Site preparation.....	20	2,800
Coal mine safety equipment.....	5	60,400
Underground equipment.....	10	2,468,600
Interim equipment replacement....	20	360,000
Total.....		3,035,700
Depreciation for field indirect, engineering, overhead and administration, contingency, fee, cost of development, and interest during development, less credit for coal mined at \$12 per ton.....	20	573,900
Grand total.....		13,609,600

¹\$1.20 per ton.

TABLE B-5. - Power and water requirements, 3-MM-tpy mine

Number of units	Operation	Hp per unit	Hp, total load	Hr per day, full load	Kw, total load	Total kwhr requirement
4	Longwall units.....	1,200	4,800	16	3,581	57,296
4	Continuous miner.....	600	2,400	10	1,790	17,900
4	Loading machine.....	160	640	10	477	4,770
8	Shuttle car.....	135	1,080	10	806	8,060
4	Roof bolter.....	50	200	12	149	1,788
4	Ratio feeder.....	125	500	10	373	3,730
4	Auxiliary fan.....	15	60	18	45	810
8	Mantrip Jeep.....	15	120	4	90	360
6	Mechanic Jeep.....	15	90	15	67	1,005
6	Personnel Jeep.....	7.5	45	15	34	510
3	Supply motor.....	80	240	12	179	2,148
5	Rock duster.....	30	150	12	112	1,344
12	36-inch belt conveyor	100	1,200	16	895	14,320
1	Ventilation fan.....	500	500	24	373	8,952
	Extra for pumps, bolting, etc.....		400	10	298	2,980
	Shops, lighting, etc.			24	482	11,568
	Total.....					137,541

NOTE:--Power at \$0.015 per kw/hr.

= \$0.015 x 137,541 x 220 day per year = \$453,900.

Water at \$0.15 per 1,000 gallons:

Continuous-miner units at 3,000 gallons per unit per shift

= (3,000 x 3 x 4 x 220 x \$0.15) ÷ 1,000 = \$1,200 per year.

Longwall units at 6,000 gallons per unit per shift

= (6,000 x 3 x 4 x 220 x \$0.15) ÷ 1,000 = \$2,400 per year.

Outside water, showers, etc., at 30 gallons per man-day

= (30 x 366 x 220 x \$0.15) ÷ 1,000 = \$400 per year.

Total water cost = \$1,200 + 2,400 + 400 = \$4,000 per year.

TABLE B-6. - Estimated annual operating cost, 3-MM-tpy mine

	Annual cost	Cost per ton
Direct cost:		
Production:		
Labor.....	\$3,137,100	\$1.04
Supervision.....	835,600	.28
Total.....	3,972,700	1.32
Maintenance:		
Labor.....	699,300	.23
Supervision.....	90,200	.03
Total.....	789,500	.26
Operating supplies:		
Mining machine parts.....	1,935,200	.64
Lubrication and hydraulic oil.....	484,000	.16
Roof bolts and timber.....	871,000	.29
Rock dust.....	484,000	.16
Ventilation.....	725,600	.24
Bits.....	237,400	.08
Cables.....	151,000	.05
Miscellaneous.....	296,800	.10
Total.....	5,185,000	1.72
Power.....	453,900	.15
Water.....	4,000	-
Payroll overhead (40 percent of payroll).	1,904,900	.63
Union welfare ¹	3,111,300	1.04
Indirect cost:		
15 percent of labor, supervision, and supplies.....	1,492,100	.50
Fixed cost:		
Taxes and insurance, 2 percent of mine cost.....	1,086,800	.36
Depreciation.....	3,609,600	1.20
Total.....	4,696,400	1.56
Grand total.....	21,609,800	7.18

¹Effective Dec. 6, 1974, under the Bituminous Wage Agreement of 1974.

TABLE B-7. - Estimated development cost,¹ 3-MM-tpy mine

Item	Total cost	Cost per ton
Total labor and supervision.....	\$2,601,200	\$4.05
Operating supplies.....	2,781,300	4.33
Power.....	198,800	.31
Payroll overhead.....	1,040,500	1.62
Union welfare.....	896,800	1.39
Indirect cost.....	807,400	1.25
Fixed cost.....	925,000	1.44
Total.....	9,251,000	14.39

¹Estimated development cost covers the period of time required (1 calendar year) to place all units in operation within the projected mining plan.

NOTE: Cost per ton = \$14.39.

Tonnage = 642,725.

Credit for coal mined at \$12 per ton = \$7,712,700.

TABLE B-8. - Estimated working capital and total capital investment, 3-MM-tpy mine

Estimated working capital:

Direct labor.....3 months...	\$1,190,600
Operating supplies.....do.....	1,296,300
Payroll overhead.....do.....	476,200
Indirect cost.....4 months...	497,400
Fixed cost.....0.5 percent of insurance base...	271,700
Spare parts.....	592,700
Miscellaneous.....	65,900
Total working capital.....	4,390,800

Total estimated capital investment:

Total mine cost (insurance, tax base).....	54,341,000
Interest during development.....	2,220,200
Total.....	56,561,200
Working capital.....	4,390,800
Estimated initial capital investment.....	60,952,000
Estimated deferred capital investment.....	33,282,700
Total capital investment and deferred investment.....	194,234,700

¹This is an average investment of \$31.31 per ton of annual production.

TABLE B-9. - Summary of discounted cash flow, 3-MM-tpy mine

Year	Capital investment	Cash flow	Present worth factor at 15 percent	Present worth, capital investment at 15 percent	Present worth, cash flow value at 15 percent
0	\$60,952,000	\$-60,952,000	1.	\$60,952,000	\$-60,952,000
1	360,000	10,559,600	.8696	313,100	9,182,600
2	360,000	10,559,600	.7561	272,200	7,984,100
3	360,000	10,559,600	.6575	236,700	6,942,900
4	360,000	10,559,600	.5718	205,800	6,038,000
5	673,000	10,246,600	.4972	334,600	5,094,600
6	360,000	10,559,600	.4323	155,600	4,564,900
7	360,000	10,559,600	.3759	135,300	3,969,400
8	360,000	10,559,600	.3269	117,700	3,451,900
9	360,000	10,559,600	.2843	102,300	3,002,100
10	25,816,700	-14,897,100	.2472	6,381,900	-3,682,600
11	360,000	10,559,600	.2149	77,400	2,269,300
12	360,000	10,559,600	.1869	67,300	1,973,600
13	360,000	10,559,600	.1625	58,500	1,715,900
14	360,000	10,559,600	.1413	50,900	1,492,100
15	673,000	10,246,600	.1229	82,700	1,259,300
16	360,000	10,559,600	.1069	38,500	1,128,800
17	360,000	10,559,600	.0929	33,400	981,000
18	360,000	10,559,600	.0808	29,100	853,200
19	360,000	10,559,600	.0703	25,300	742,300
20	-21,680,800	32,600,400	.0611	-1,324,700	1,991,900
				68,345,600	3,300

TABLE B-10. - Discounted cash flow analysis, 3-MM-tpy mine

15 percent - 20 years

$$R = \$68,345,600 \div 6.259^1 = \$10,919,600$$

less depreciation	3,609,600
Depletion + net profit	<u>7,310,000</u>

Depletion = 10 percent of sales

Federal income tax = net profit

Depletion + net profit = cash flow - depreciation

$$\begin{aligned} \text{Sales} &= 1.0/0.55 (1/2 \text{ operating cost} + \text{cash flow} - \text{depreciation}) \\ &= 1/0.55 [(1/2 \times \$21,609,800) + \$7,310,000] \\ &= 1/0.55 (18,114,900) \\ &= \$32,936,200 \end{aligned}$$

Sales.....	\$32,936,200
Operating cost.....	21,609,800
Gross profit.....	11,326,400
Depletion.....	<u>-3,293,600</u>
Taxable income.....	8,032,800
Federal income tax.....	<u>-4,016,400</u>
Net profit.....	4,016,400

$$\begin{aligned} \text{Annual cash flow} &= \text{net profit} + \text{depletion} + \text{depreciation} \\ &= \$4,016,400 + \$3,293,600 + \$3,609,600 \\ &= \$10,919,600 \end{aligned}$$

$$\text{Selling price per ton} = \$32,936,200 \div 3,009,600 = \$10.94$$

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